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FEASIBILITY STUDY OF PIEZOTRANSISTOR ACCELEROMETER

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A major portion of this reporting period has been concerned with efforts to design a transducer for an accelerometer based on the piezo-junction effect. Due primarily to the difficulty in handling the small silicon needles, which are the basic sensors of the planned accelerometer, this effort programmed slowly.

A significant amount of time has been devoted to the development of a process for fabricating a four-layer switching device in the form of a needle. The progress of this work is inherently slow due to a necessity that the first of the three diffusions be extremely deep. This diffusion must be on the order of 10 microns in depth with a low surface dopant concentration and requires approximately 64 hours in the diffusion furnace. An unsuccessful attempt to fabricate one of these devices consumes a considerable amount of time while contributing only information applicable to the next attempt.

Two processes for fabricating silicon needle stress sensors have been developed--a mesa and a planar process. Some stability problems were encountered with sensors made by the mesa process due to surface problems at the exposed junctions. This was particularly noticeable in attempts to fabricate four-layer devices by this process. The planar process was developed for single junction needle devices to alleviate this problem, and is presently being worked out for application to four-layer devices.

The first step in the design of an accelerometer based on the silicon needle stress sensor was to develop a suitable method of mounting the needle. Some difficulty was encountered finding a method which would provide the needle with both mechanical support and electrical contact.

One method attempted was to make use of the relatively low eutectic temperature of silicon and gold. Tantalum and molybdenum tabs were gold electroplated and a jig made to hold the needles in place on the tab while the temperature of the assembly was raised above this silicon-gold eutectic temperature. Fairly good eutectic bonds were obtained, however the mechanical support provided by these bonds were insufficient to hold the needles in place.

The present needle mounting technique utilizes a metal bracket for mechanical support and conductive epoxy for electrical contact. The metal bracket is fabricated from tantalum and has a hole punched in it so as to firmly hold the needle when it is wedged into the hole. The tantalum tab is then welded to a conventional transistor header leaving the needle pointing perpendicularly away from the surface of the header. A small amount of conductive epoxy is placed between the base of the needle and the header before welding so as to provide electrical contact.

The main problem presently confronting the successful design of an accelerometer is that it is extremely difficult to place an electrical contact and seismic mass onto the tip of the needle without fracturing the tip. Several methods are now in the development process; one of

which is expected to solve this problem. All of these techniques provide a means through which the initial load on the tip of the needle can be mechanically adjusted.

One of these methods is to mount the needle onto a tantalum tab exactly as described above. This tab would then be mounted onto an aluminum base by a method which would provide electrical isolation. Directly beneath the tip of the needles a hole would be drilled in the base and threaded with very fine threads. A conductive screw could be turned into the threaded hole until electrical contact with tne needle is obtained. A seismic mass would be placed on the metal tab directly above the needle, which would apply an acceleration-dependent force on the device.

It has been observed during the course of this work and by others in the field that the reverse breakdown voltage characteristics of a p-n junction is related to applied stress. The theoretical explanation of this effect is presently being reviewed and its usefulness investigated.

The objective of the next quarter will be to incorporate all of these intermediate developments into an operable laboratory accelerometer capable of demonstrating the piezojunction phenomenon. The development process now under way for fabricating four-layer switching devices in needle form will be continued.